CLAIMS

1. A hairspring intended to equip the balance wheel of a mechanical timepiece and in the form of a spiraled rod (10) cut from an {001} single-crystal silicon plate, the turns of which have a width w and a thickness t, characterized in that said silicon rod is structured and dimensioned so as to minimize the first thermal coefficient (C_1) and the second thermal coefficient (C_2) of its spring constant C.

2. The hairspring as claimed in claim 1, characterized in that, in order to minimize the first thermal coefficient (C_1), said rod comprises a silicon core (12) and an external layer (14) of thickness ξ formed around the silicon core and made of a material having a first thermal coefficient of Young's modulus opposite that of silicon.

3. The hairspring as claimed in claim 2, characterized in that said external layer (14) is made of amorphous silicon oxide (SiO_2).

4. The hairspring as claimed in claim 3, characterized in that the thickness ξ of said external layer (14) represents about 6% of the width w of the rod.

5. The hairspring as claimed in claim 1, characterized in that, in order to minimize the second thermal coefficient (C_2), the width of said rod is modulated, periodically, as a function of the angle θ that defines the orientation of each of its points in polar coordinates.

6. The hairspring as claimed in claim 1, characterized in that, in order to minimize the second thermal coefficient (C_2), the width of said rod is

modulated so that its local flexural stiffness is constant.

7. The hairspring as claimed in claim 6, characterized in that the modulation is effected according to the formula:

$$w = w_0 \sqrt[3]{1 - \frac{1 - \frac{\overline{S}_{12.0}}{\overline{S}_{11.0}} - \frac{1}{2}\frac{\overline{S}_{44.0}}{\overline{S}_{11.0}}}{2} \sin^2(2\theta)}$$

in which $\overline{S}_{11}$, $\overline{S}_{44}$ and $\overline{S}_{12}$ are the three independent elastic coefficients of silicon along the crystallographic axes.

8. The hairspring as claimed in claims 2 and 5, characterized in that, in order to minimize the first thermal coefficient (C_1) and the second thermal coefficient (C_2), the thickness t of the rod, its width w in the {100} plane and the thickness ξ of the silicon oxide layer have values for which the thermal drift of the spring constant C of the hairspring is a minimum within a given temperature range.

9. A method for determining the optimum dimensions of the hairspring as claimed in claim 8, characterized in that it consists, in succession, in:

- mathematically expressing the stiffness of the hairspring as a function of its thickness t, its width w modulated in the plane of the hairspring, the thickness ξ of the silicon oxide layer, the elastic anisotropy of the silicon and the temperature;
- calculating the thermal behavior, in particular the first two coefficients (C_1, C_2) of the spring constant of the hairspring for all combinations of possible values of the parameters t, w and ξ within a given temperature range; and
- adopting the t, w, ξ combinations for which the thermal drifts of said coefficients (C_1 and C_2) are minimal.

10. The method as claimed in claim 9, characterized in that it consists, finally, in calculating the width w of the spiral at any point from the formula:

$$w = w_0 \sqrt[3]{1 - \frac{1 - \frac{\overline{S}_{12.0}}{\overline{S}_{11.0}} - \frac{1}{2}\frac{\overline{S}_{44.0}}{\overline{S}_{11.0}}}{2} \sin^2(2\theta)}$$

in which $\overline{s}_{11}$, $\overline{s}_{44}$ and $\overline{s}_{12}$ are the three independent elastic coefficients of silicon along the crystallographic axes.